prices. Specifically, the calculation includes two components: the rail cost recovery index and the rail productivity index.

For the price cap calculation for AT&T and eventually the Local Exchange Carriers (LECs) a differential approach was explored to overcome perceived problems in directly measuring telecommunications input price indices. While a fully specified differential approach is theoretically consistent with the direct approach employed by the ICC, the differential approach requires substantially more information -- all of it subject to various forms of potential error.[19] Essentially this approach seeks to measure the change in the telecommunications sector's output price by adjusting the output price of the overall economy by the difference in overall productivity gains between the economy and the telecommunications sector and the difference in input cost measures.

To this theoretically valid differential approach, various parties offered simplifying assumptions that resulted in a *modified differential approach* that was adopted by the FCC in the original LEC price cap formula.[20] Specifically, this approach seeks to measure the change in the costs of factors of production for the telecommunications industry by utilizing a broad-based, general economic price measure (in this case the GDP-PI) and then adjusting for an estimated differential between telecommunications and economy-wide productivity growth.[21] This approach is consistent with the underlying methodology embedded in the USTA's TFP method, with the caveat that the productivity differential is measured through TFP calculations.

1.2.2 Critical Biases in the Modified Differential Approach

Sources of potential error can be identified within the modified differential approach that are beyond the measurement issues of productivity as contained in the X-Factor, the current source of much discussion by the various parties to the proceedings. Specifically, the sources of bias

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[19] The differential approach to price cap calculations is specified as $dp^L = dp^N - (dTFP^L - dTFP^N) + (dw^L - dw^N)$ where the d(•) operator indicates annual percentage change, the superscript L denotes LEC, the superscript N denotes the overall U.S. economy and p is the relevant output price, w is the relevant input price, and TFP is the relevant total factor productivity.

[20] The modified differential approach can be generally described as $dp^L = dw^N - (dTFP^L - dTFP^N)$, where the d(•) operator indicates annual percentage change, the superscript L denotes LEC, the superscript N denotes the overall U.S. economy and p is the relevant output price, w is the relevant input price, and TFP represents the relevant productivity. Although the current LEC Price Cap Plan does not explicitly measure the productivity differential based on a TFP method, we retain the TFP representation in the formula for the modified differential approach for simplicity.

[21] FCC Second Further Notice of Proposed Rulemaking, CC Docket No. 87-313, Released 4/13/89, p. 314.

within the current LEC formula include: 1) the use of an aggregate inflation measure as a proxy for the price changes in a given sector of the economy, particularly when that sector's input prices have exhibited unique characteristics; 2) the selection of the GDP-PI as the measure of aggregate inflation; and 3) the exclusion of a measure of the input price differential between telecommunications and the general economy based on the assumption that the differential is zero.

1. The measure of inflation employed within the price cap formula plays an important role in the accuracy of telecommunications price cap levels.[22] There has been some discussion in the literature concerning the problems associated with the use of general price indices to measure the change in a specific sector's input prices.[23] For example, Ferenc Kiss points out in one study that "the chief danger in using external price indices is that they may not be capable of reflecting accurately the input price index of the regulated firm and thereby they may increase the exogenous deviations."[24] In fact, the findings of this same study revealed that the deviations between AT&T's input price and the economy-wide measure have been significant over history.

2. Compounding the problems associated with the use of a general measure of economy-wide inflation in the price cap formula is the inherent problems in selecting the appropriate index. A review of the record indicates that the current LEC price cap formula employs an inappropriate measure of price change (i.e., the GDP-PI) relative to the intent of the specified modified differential formula. The modified differential approach seeks to measure the change in the costs of factors of production for the telecommunications industry through the use of the GDP-PI. However, a conceptual review of the composition of the economy will confirm that the GDP-PI *neither represents the market for factors of production, nor does it represent economy-wide output prices.* Rather, the GDP-PI represents approximately one-third of the economy covering sales to final demand; two-thirds of that are personal consumption expenditures. *Two-thirds of the total economy representing all non-capital*

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[22] Federal Communications Commission, *Further Notice of Proposed Rulemaking*, CC Docket No. 87-313, Released May 23, 1988, p. 197.

[23] Interestingly, several parties, including various state-level public service commissions, argued for the implementation of a telecommunications-specific price index. In this calculation of an industry-specific index some parties proposed that a combination of NARUC, USTA and state agencies work "to develop a single national index that reflects both changes in telecommunications input prices and changes in productivity." See: FCC Further Notice of Proposed Rulemaking, CC Docket No. 87-313, Released May 23, 1988, p. 194. This approach is consistent with the role of the AAR within the ICC price regulation proceedings

[24] F. Kiss "Constant and Variable Productivity Adjustments for Price-Cap Regulation", in M. A. Einhorn, *Price Caps and Incentive Regulation in Telecommunications*, Boston, MA: Kluwer Academic Publishers (1991), p. 99.

domestic business-to-business transactions are excluded from the GDP-PI. The use of GDP-PI compared with the correct economy-wide price index of output based on measured economy-wide transactions would result in a substantial upward bias in the rate of estimated LEC price changes.

3. In addition, the theory underlying the differential price cap methodology requires the explicit incorporation of the difference in input prices between the economy and the telecommunications industry in order to accurately estimate the permitted increase in output prices. However, the price cap calculation that was adopted for the LEC price cap formula implicitly assumes that this differential is zero by dropping this component from the equation. *The accuracy of a differential price cap approach that ignores the input price component is impacted by this overly restrictive assumption.* Such an assumption ignores the inherent input differences of the economy as a whole and the telecommunications sector and the empirical evidence that the telecommunications sector has over a thirty year period been supplied, on average, by sectors whose own TFP have substantially exceeded the economy-wide rate of productivity growth.[25] The assumption that the input price differential is zero, therefore, unnecessarily introduces a bias into the calculation.

[25] As discussed in **Section 3.3**, the telecommunications sector represents 1.8 percent of the total economy in 1993. In addition, its purchases are compositionally different from both GDP-PI and an index representing economy-wide input purchases. Those key supplying sectors (e.g., electric machinery) to telecommunications have consistently demonstrated above average rates of productivity growth over the last thirty years.

1.2.3 A Measurable Impact on LEC Price Caps

Therefore, in comparing a fully and correctly specified differential approach with the modified differential approach over the 1985-1993 period, we find that the GDP-PI consistently overstates economy-wide product price inflation by over .8 percent per year and that aggregate input prices exceed telecommunications input prices by about .9 percent per year since 1985.[26] Thus, the modified differential approach overstates resultant LEC output price by 1.79 percent per year. Comparing the modified differential approach with the direct approach employed by the ICC, we find that the aggregate price index (the GDP-PI) overstates telecommunications input price changes by about 1.5 percent per year and that the X-Factor is smaller since it nets out aggregate productivity. In other words, a smaller TFP offset is deducted from a larger price increase, resulting in an error of 1.79 percent per year in permitted LEC output prices, assuming an aggregate TFP of .29, as estimated by the BLS, over the 1985 to 1993 period. Since the full differential approach and the direct approach should each produce equivalent correct estimates, it is not surprising that we obtain equivalent comparative biases when measured relative to the errors in the modified differential approach.

Adoption of a direct price cap framework, such as the ICC's approach to rail price regulation, employing an industry-specific input price index and TFP would eliminate much of the confusion and bias inherent in the modified differential approach. Alternatively, a fully specified differential approach utilizing an appropriate measure of aggregate inflation and correct and consistent input price indices, although more complex, would correct for some of the current biases inherent in the LEC's modified differential approach.

1.3 Study Objective

The FCC has explicitly recognized the complexities introduced into the price cap formula by relying on the current LEC price cap approach rather than on a direct approach.[27] The objective of this analysis is to review the price cap formula underlying the LEC price cap approach and now incorporated in the USTA's TFP method, relative to specific issues raised by the FCC in the Fourth Further Notice. We focus on the role of the price change measurements within a price cap

[26] A fixed-weight labor price index covering telecommunications is only available from 1985.
[27] *Fourth Further Notice*, pp. 23-24

regime and the implications the selection of alternative formula specifications and price indices can have for the overall accuracy of the price cap measure. Specifically, we present evidence concerning the biases embedded in the modified differential approach within the context of several related issues raised by the FCC in its *Notice*:

1. "the desirability of measuring LEC unit cost growth directly, rather than by offsetting inflation by an X-factor."[28] We will address trends in LEC input prices, specifically relative to the exclusion of the input price differential from the LEC price cap formula.

2. "the most reasonable way to account for changes in LEC's input prices for use in a TFP approach to calculating the X-Factor."[29]

3. the reasonableness of the "imputation of capital services from capital stock rather than from capital consumption".[30]

4. "the most reasonable method for developing an implicit rental price."[31]

5. "the most reasonable method for developing a labor index."[32]

6. "the most reasonable method for developing a materials index."[33] Or more directly, "as a theoretical and practical matter, it would be preferable to construct a price index for materials instead of relying on GDP-PI."[34]

The report is structured in three sections. **Section 2** provides an overview of a practical application of the direct approach to determining price caps. In this section an historical review of the evolution of price cap regulation at the Interstate Commerce Commission is presented. **Section 3** presents the conceptual and theoretical basis for the calculation of price caps. Within this context, we provide a comparison of the current LEC price cap formula with the ICC's framework. We also describe the conceptual double entry accounting system for the economy that allows critical information on the input prices for the aggregate economy and the

[28] *Ibid*, p. 24.
[29] Ibid, Issue 1i, p. 22.
[30] Ibid, Issue 1e. p. 19.
[31] Ibid, Issue 1f. p. 20.
[32] Ibid, Issue 1g. p. 21.
[33] Ibid, Issue 1h. p. 21.
[34] Ibid, p. 21.

telecommunications sector to be measured and compared. In **Section 4** the underlying compositional variances between the price indices for a theoretically correct differential framework and those indices actually employed within the current modified differential approach are measured and compared. In **Section 5.0** we present a comparison of the price caps resulting from the modified differential price cap framework with the conceptually correct calculated indices under both the full differential approach and the direct approach employed by the ICC.

2.0 The Direct Approach: A Practical Application

2.1 Introduction

Both the railroad and telecommunications industries have long been regulated by the Federal government. Under efforts to transition towards more competitive markets, both the ICC and FCC have implemented a price cap approach to alternative regulation. While the current LEC price cap calculation employs a modified differential approach, the ICC has pursued a direct approach to the price cap calculation for the rail system. In this section we present a brief review of the ICC's price cap approach in order to demonstrate a simple, workable and practical approach to implement the direct approach to price cap calculations. The ICC experience points to the desirability of a direct measure of price caps relative to the more complex and data limited differential or modified differential approach.

2.2 The ICC Experience, 1980 - 1989

Similar to the telecommunications sector, the railroad industry has been subjected to various state (the Granger Laws) and federal (the Interstate Commerce Act, the Hepburn Act of 1906, the Transportation Act of 1920) regulations for decades.[35] At the federal level, these various measures provided for the Interstate Commerce Commission (ICC) to govern maximum and minimum rates, service changes, abandonment of unprofitable lines and ownership issues. With the Staggers Act of 1980 the railroads became part of the recent deregulation trend. Although the Staggers Act did not totally deregulate the industry, it did substantially reduce regulations. Relative to the rails' pricing practices, the Staggers Act provided for significant pricing freedom. In fact, in markets without carrier dominance, maximum rail prices are not subject to ICC oversight.[36]

Under the Staggers Act, the ICC also allowed for railroads to increase their rates based on the Rail Cost Adjustment Factor. Initially, this adjustment factor measured the change in input costs, including the quality and mix of material, fuel, capital and labor. The ICC explicitly ruled out

[35] F. Stephenson, Jr., *Transportation USA*. Reading, MA: Addison-Wesley Publishing Co. (1987), p. 115
[36] D. Wood and J. Johnson, *Contemporary Transportation*, 3rd edition. New York: MacMillan Publishing Co. (1989), p. 138.

the use of readily available, standard economic measures of cost escalation such as the PPI for the reason that such measures are too broad and "include many elements unrelated to rail costs."[37] The ICC accepted the American Association of Railroads' calculation of the Rail Cost Adjustment Factor, subject to certain modifications. A PPI was applied only in the interim to certain categories such as durable assets excluded from the AAR index. An "all inclusive index" (IIA) created by the AAR and modified through input of federal and state governments, individual shippers, shipper associations, trade associations and the Commission was approved and implemented in January 2 1985.[38] The IIA is a fixed weight input price index comprising seven components. The index weights are calculated from annual operating expense data for all Class I railroads. The AAR submits a one-quarter forecast of this index, which is used by the ICC to calculate the Rail Cost Adjustment Factor.

Interestingly, at the time of introduction of the Rail Cost Adjustment Factor, the ICC determined that productivity adjustments would not be incorporated within the adjustment factor calculation for several reasons, including the lack of an appropriate productivity methodology and the rails' financial problems.[39] This exclusion of an explicit productivity offset in the RCAF resulted in complaints by shippers at the time of implementation. Furthermore, the 1982 Caves-Christensen study detailed the role of productivity within the RCAF and proposed a potential methodology to more accurately calculate the appropriate rate adjustment factor. In this study, the authors make the point that a common recommendation of economists for adjusting rates is to calculate an input price index adjusted for productivity growth.[40] In fact, this is the straightforward methodology the authors pursue in their 1982 study, and it is this methodology that is then generally accepted (with some modifications) in 1989 when the ICC determined that productivity offsets should be included within the RCAF.[41] Ultimately, a productivity offset was incorporated by the ICC into the price cap calculation in 1988.[42]

The ICC's approach to rail regulation as it has evolved over the last decade has, therefore, resulted in a relatively simple calculation for adjusting the maximum cap on rail rates. Specifically, the calculation includes two components: the cost recovery index (previously the RCAF) and the productivity index. The productivity index is determined by the index of rail

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[37] *Ex Parte* No. 290 (November, 1980), pp. 3.
[38] *Ex Parte* No. 290 (January, 1985), p. 7.
[39] Ibid, pp. 4-5.
[40] D. Caves and L. R. Christensen, *Ex Parte* No. 290 (Sub-No. 4), "Railroad Cost Recovery Procedures -- Productivity Adjustment," verified statement taken October 25, 1982, p. 13.
[41] *Ex Parte* No. 290 "Railroad Cost Recovery Procedures - Productivity Adjustment", p. 435.
[42] Ibid, p. 434.

output, adjusted by the input cost index. This calculation does not include any complicating inclusion of economy wide price changes and productivity measures. Additionally, the ICC approach as presented in Caves and Christensen (1982) "is immune to errors in the measurement of the Cost Recovery Index [due to the fact]...that if the CRI is in error, the productivity correction will change so as to exactly offset the error".[43] In other words, since input prices are required for the productivity calculation, any error in input prices will equally effect both the measure of productivity as well as the cost recovery index -- netting out any errors from the price cap.

Other simplifying factors in the ICC approach to rate regulation ensure conformity to the intent of the Staggers Act to simplify the procedures for increasing rail rates. For example, rather than requiring the development and calculation of capital usage and price for the sole purpose of the price cap procedure, the ICC allowed the value of capital to be determined by the regulatory definition already in effect. That is, the ICC employed depreciation as the measure of capital usage and indexed it to a BLS producer price index for capital.

[43] For the proof of this conclusion see: Caves and Christensen, October 25, 1982, p. 16.

3.0 A Price Cap Methodology

3.1 Introduction

The previous section outlined the practical implementation of a direct price cap regime by the ICC to determine maximum rail prices. The simplicity and reasonableness of this method supports the desirability of such a measure for the telecommunications sector. Such a view, however, is also supported by a review of the assumptions currently embedded within the modified differential approach employed in the USTA's TFP method and in the current LEC price cap formula. In this section we present conceptual and compositional differences between the modified differential approach, a correctly implemented differential price cap formula, and a direct price cap formula supported by a framework that captures consistent economy-wide activity.

Section 3.2 presents a brief discussion of the alternative specifications of the direct price cap approach relative to a theoretically correct differential approach, and the modified differential approach, and identifies potential problems. **Section 3.3** addresses how the necessary components of a LEC price cap formula might be constructed to more accurately reflect the changes in the telecommunications sector. In fact, much progress on these issues can be made by reviewing the two-dimensional system-wide, sectoral and market representations of economic activity often employed in interindustry analysis.

3.2 The Economic Theory of Price Caps

As discussed previously in earlier related proceedings,[44] the economic theory underpinning price caps expresses the allowed price changes as:

$$dp^L = dw^L - dTFP^L \quad (1)$$

$$dp^N = dw^N - dTFP^N \quad (2)$$

[44] AT&T Reply Comments, CC Docket No. 94-1 (June 29, 1994). Also, see FCC *First Report and Order*, Appendix F, Released 4/7/95.

where the d(•) operator indicates annual percentage change, the superscript L denotes LEC, the superscript N denotes the overall U.S. economy and p is the relevant output price, w is the relevant input price, and TFP is the relevant total factor productivity.[45]

Equation (1) is the direct measurement framework ultimately implemented by the ICC.[46] This formula is relatively simple, straightforward, and deals appropriately with the scope of the industry in question.[47] This, however, was not the formulation adopted in the original LEC price cap formula. Rather, some parties to the 1987-1990 proceedings argued for an approach based on a differential method in order to overcome the need to directly measure input prices for the telecommunications sector.[48] This differential method was then *modified* to the following specification:

$$dp^L = dw^N - (dTFP^L - dTFP^N) \qquad (3)$$

The modified differential approach incorporates a "broad based" factor price index and an estimated difference in productivity between the overall economy and telecommunications. The current LEC price cap formula does not explicitly measure the productivity differential based on a TFP method, although the USTA TFP method does propose a TFP approach to measuring the productivity differential. In the formula for the modified differential approach we retain the TFP representation for the productivity measure for simplicity.[49] Equation (3), however, is not an accurate representation of the underlying drivers of telecommunications output prices. In fact, this approach excludes important information that would improve the accuracy of the price cap formula.

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[45] For simplicity we will assume no change in profits for both the sectoral and economy-wide equations.

[46] The ICC incorporated rail productivity measurements into their price cap methodology in 1988. see. Ex Parte 290 Sub-No. 4, p. 434.

[47] In 1993, railroads represent about 3 percent of total economy output. Telecommunications represents about 1.8 percent.

[48] Originally, the FCC stated its interest in selecting an inflation measure representing the changing costs for factors of production.

[49] The FCC's 1989 Second Further Notice of Proposed Rulemaking established a 2.5% productivity measure for AT&T based on information derived from several TFP studies (see pp. 104-106). At that time, the FCC also found no evidence that this number should be any different for the LEC's price cap formula (see p. 322). The LEC price cap formula currently reflects an offset whose origin lies in the same TFP studies employed to determine AT&T's offset plus two non-TFP studies -- the Frentrup-Uretsky short-term study and the Spavins-Lande long-term study (FCC *Fisrt Report and Order*, released April 7, 1995, p. 90). Following reviews of these studies, the productivity offset in the LEC price cap formula was set at 2.8, with an additional .5 Consumer Productivity Dividend. Later, after further reviews, the offset was raised to 4.0. However, the central focus of our review is to examine the specification of the price cap formula and supporting price indices, rather than focus on the calculation of the productivity component of the X-factor.

A true differential approach would account for the differences in economy-wide output price changes and telecommunications output price changes by measuring the differences in changes in total factor productivity and input prices. Returning to equations (1) and (2), one can meaningfully express the difference between changes in economy-wide output prices and telecommunications output prices by subtracting equation (2) from equation (1) and rearranging terms:

$$dp^L = dp^N - (dTFP^L - dTFP^N) + (dw^L - dw^N) \quad (4)$$

Equation (4) states that the change in LEC output prices is equal to the change in national output prices, minus the difference in TFP changes, plus the difference in factor input price changes. Therefore, ignoring all conceptual and empirical issues involving the measurement of productivity, there are two broad problems with equation (3), the modified differential approach.

1. The aggregate price index is misspecified:

   a) The LEC price cap record focused on selecting a price index of national factor inputs, dw^N. This appears to result from some confusion regarding equation (1), which requires a price index of LEC factor inputs, dw^L, and equation (4), which requires a price index of national output prices, dp^N, and $(dw^L - dw^N)$. Either formulation (i.e. equation (1) or equation (4) would be correct. However, an expression such as equation (3), which only employs dw^N as a price index, misspecifies the underlying price cap theory.

   b) The measure subsequently chosen to represent dw^N was the GDP-PI. The GDP-PI is a price index of final product sales, not of factor inputs.[50]

   c) Even if one makes the substitution dp^N for dw^N in equation (3), the use of GDP-PI as a measure of the change in the economy-wide output price severely biases the formula. GDP-PI is a price index representing approximately one-third of the economy -- i.e., sales to final use -- primarily to personal consumption expenditures. The GDP-PI does not incorporate any non-capital domestic business to business sales. In fact, the material input composition is dramatically different between GDP and economy-wide product.

[50] Additionally, as discussed by Kiss, the use of GDP-PI in equation (3) implies that "the economy cannot have a productivity improvement." (see: Kiss, p. 112). This signifies that the productivity gain measured in equation (3) "is not the deviation from the economy s productivity gain but the entire productivity gain of the telecommunications industry."

It is important to note that use of a productivity differential, together with a price index representing final demand as in equation (3), means that relative to the correct formulation in equation (1), *a smaller TFP differential is deducted from a larger price index,* producing a compounded upward bias in permitted LEC output prices. Furthermore, $dTFP^N$ is totally unnecessary in equation (1). Swings in $dTFP^N$ due to BLS revisions or updates introduce substantial potential bias, even when the correct differential formula is employed (i.e. equation (4)).

2. Equation (3) fails to incorporate the differential in input prices, assuming that this differential is explicitly zero. Telecommunications represents only 1.8 percent of total gross output. There is no reason to assume an equality of input composition between telecommunications and the economy. In fact, the relative shares of labor, capital and material inputs to the telecommunications sector varies significantly from the economy as a whole. Further, the underlying composition of telecommunications capital and material purchases is much different from the overall economy.

Below, a discussion of the framework and calculations supporting these conclusions is provided.

3.3 A Double-Entry Accounting Framework

In exploring a differential approach to price cap calculations, the FCC pointed to difficulties in measuring the telecommunications input prices necessary for the direct approach pursued by the ICC. Furthermore, in evaluating substitute measures of costs for use in the differential approach the FCC settled for the GDP-PI as a measure reflecting the change in prices for the overall economy. However, a valid, verifiable, and available government-collected information set in the form of an interindustry or input-output frameworks could have solved both these problems -- allowing for either a directly calculated telecommunications input cost index or, if the differential approach remained the preferred method, a significantly more accurate measure of total economy-wide price changes. This framework provides a mechanism for comprehensively tracking and analyzing the goods and services that individual sectors buy from and sell to each other. In addition, the accounting traces each sector's sales to final use (i.e. GDP-PI) and its purchases of primary inputs (i e. capital and labor). As a result, such a system allows for the measurement of total economic activity, not simply the goods and services sold to final consumers.

3.3.1 Framework Overview

Empirically constructed input-output accounts are usually developed using data on dollar-valued transactions occurring throughout a given year.[51] This information is most commonly presented as a *double-entry accounting system.* Within the intermediate goods portion of the system, each sector is recorded twice -- once as a row showing the distribution of its output to other sectors and once as a column showing its purchases of inputs from other sectors. The distinction between intermediate and final users of sectoral outputs and the purchases of intermediate (produced) and primary (labor and capital) inputs enable the input-output table to be divided into 3 quadrants, as shown in **Exhibit 1** below.[52]

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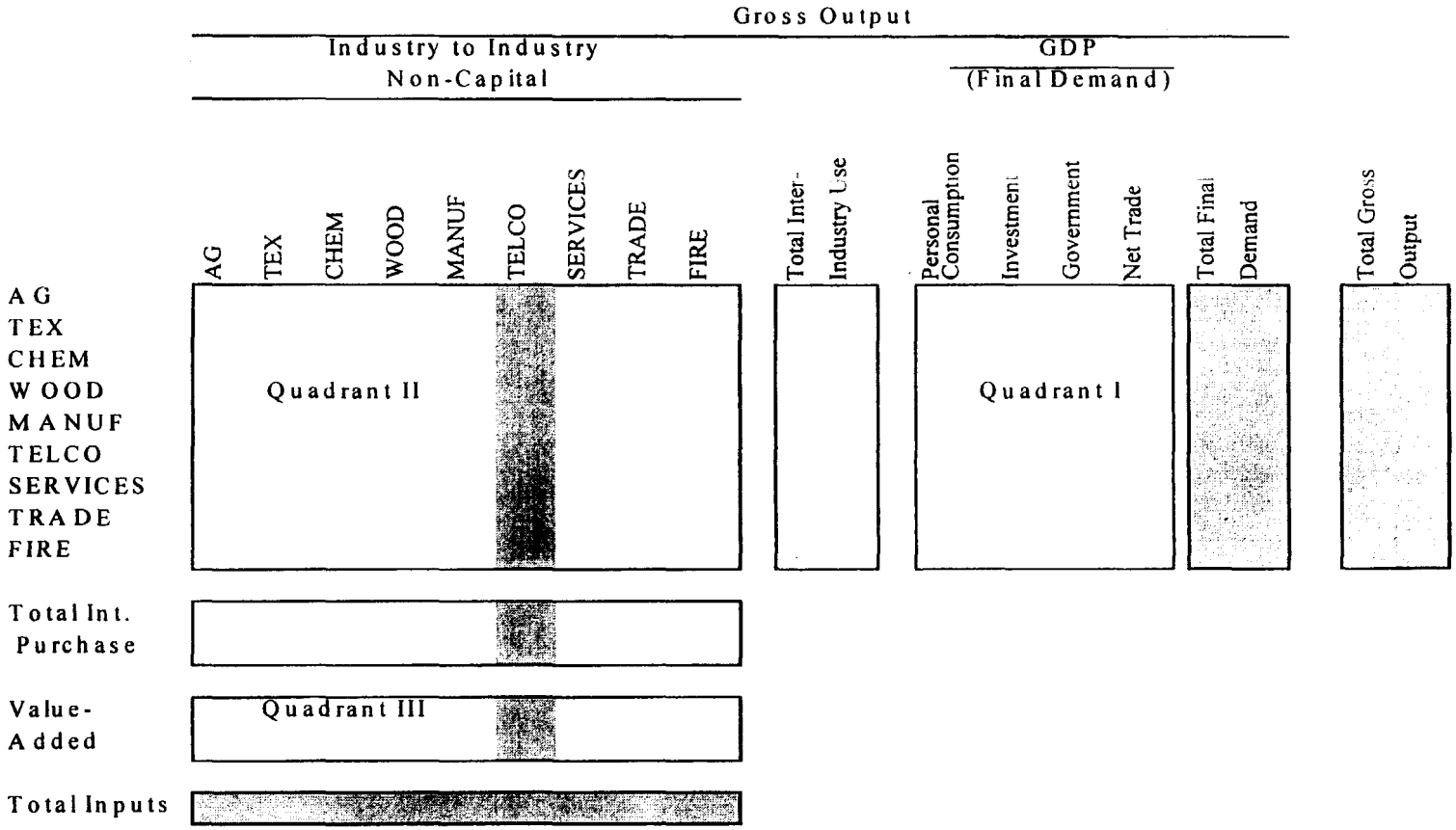
[51] A series of census-based input-output tables are produced and released by the Bureau of Economic Analysis (BEA) on approximately a five year schedule. Annual survey-based tables are released between benchmark releases.

[52] In concept, an implied Quadrant IV (hence the terminology of "quadrant") depicts payments to primary factors by final expenditure categories. Although the inclusion of these transactions is necessary for the input-output table to be consistent with the national income and product accounts, alternative accounting procedures are usually followed which allow these transactions to be identified in Quadrants I and III. In the following discussion, it is assumed that these alternative accounting procedures are followed.

Exhibit 1.
Illustrative Two-Dimensional Representation of Total Economic Activity



- Quadrant I records the deliveries of sectoral outputs to final demand.
- Quadrant II shows the distribution and deliveries of outputs among all producing sectors in the economy.
- Quadrant III records the purchases of primary inputs by each producing sector. These transactions can be disaggregated into component series, such as employee compensation, capital consumption allowances, indirect business taxes, and profit-type income.

The framework is grounded in the work of Nobel Laureate Wassily Leontief, who pioneered the analytical methods[53] and led the way in adapting the methods to a wide array of analytical applications.[54] Popular presentations of the basic interindustry frameworks abound.[55] Such models are powerful tools in the analysis of technical change.[56] Theoretical extensions and empirical applications are continually developing,[57] and are the subject of an ongoing series of international conferences.[58] The frameworks are widely used not only for national economic analysis but also regional analysis.[59]

Several features of this table deserve note:

- Adding horizontally, the deliveries to industries plus the deliveries to final demand (i.e. GDP) equal gross output for each producing sector. The horizontal pattern of deliveries differs markedly from one sector to another, reflecting the end-markets served by that sector.
- Adding vertically, each sector's purchases of inputs from other sectors (and itself) and from primary factor suppliers (e.g. labor and capital) equal total inputs. The vertical pattern of input purchases reflects the mix of inputs used to produce sector's output.
- Since the input-output table is a double-entry accounting system, each producing sector's row total (gross output) is equal to its column total (total inputs). In other words, the total

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[53] W. Leontief, *The Structure of the American Economy 1919-1939*, Harvard University Press, 1941.
[54] W. Leontief et al., *Studies in the Structure of the American Economy*, Oxford University Press, 1953.
[55] See H. Chenery and P. Clark, *Interindustry Economics*, John Wiley and Sons, 1959; W. Leontief, *Input-Output Economics*, Oxford University Press 1966; and R. Miller and P. Blair, *Input-Output Analysis: Foundations and Extensions*, Prentice-Hall, 1985.
[56] See A. Carter, *Structural Change in the American Economy*, Harvard University Press, 1970.
[57] See R. Miller, K. Polenske, and A Rose, *Frontiers of Input-Output Analysis*, Oxford University Press, 1989.
[58] The latest documented in W. Peterson, *Advances in Input-Output Analysis: Technology, Planning and Development*, Oxford University Press, 1991.
[59] See W. Isard, "Interregional and Regional Input-Output Analysis: A Model of a Space Economy," *Review of Economics and Statistics* 33, no. 4, (November 1951), pp. 318-328; Miernyk et al., *Simulating Regional Economic Development*, D. C. Heath and Co., 1970; and K. Polenske, *The U.S. Multiregional Input-Output Accounts and Model*, Lexington Books, 1980.

revenue generated from output sales is used to purchase inputs to be used in the production process or it ends up in profits.

The utility of such a double-entry accounting framework is derived from two sources. First, the information contained in the framework can be linked with annual information on employment, output, and prices in order to conduct descriptive and quantitative analysis of the economy and the interrelationships among producing sectors. For example, the input-output table incorporates a vast quantity of detail (i.e. 480 industries by 480 industries) concerning current and historically applied industrial techniques and interindustry interaction. The second use of this economy-wide accounting framework is in analyzing and predicting the performance of the economy. The framework can be used to trace how a change in productivity in one industry affects the economic system or its constituent parts; or to decompose an industry's total contribution to system-wide productivity into its direct (i.e. TFP) effect and its indirect effect.[60]

3.3.2 Data Employed in the Analysis

The double entry accounting framework is supported and updated through the integration and linking of a variety of government-compiled data sources. Below, we provide a brief description of the sources of data that make the double entry accounting framework described above both useful and dynamic.

Output

In order to support its mission to produce sector-by-sector employment projections, the Bureau of Labor Statistics' Office of Employment Projection (OEP) compiles consistent and comprehensive estimates of sectoral output and prices.[61] Output measures are compatible with the definitions and conventions of the Bureau of Economic Analysis' input-output tables. They are based on producer's value, including primary and secondary products and services. The Census and the Annual Survey of Manufactures are the main data sources for the manufacturing industries' output time series. Non-manufacturing industries' output time series are compiled with varied data sources. These sources include the Service Annual Survey, National Income and Product Accounts (NIPA), IRS data, and others. Annual output price data is developed in a

[60] See for example, F.J. Cronin, et al., "Telecommunications Technology, Sectoral Prices, and International Competitiveness." *Telecommunications Policy*. October 1992.
[61] Methodology for Input-Output Time Series Data, Office of Employment Projections, Bureau of Labor Statistics.

consistent manner to BEA's national income and product accounts. Manufacturing price data is based on industry sector price index data from the BLS. Non-manufacturing price data use several different sources.

Materials

Material inputs are defined in an input-output context as interindustry purchases. They are comprised of goods and services purchased on a current-account basis, as opposed to on a capital account basis. They are not depreciated, and are generally not expected to be used by the purchasing industry for longer than roughly three years. Material inputs include goods such as chemicals, raw materials, and electronics, and services such as insurance, advertising, and energy.

Material purchases are calculated for each sector using the Bureau of Economic Analysis' 1987 input purchase coefficients[62] and the OEP estimates of annual sectoral output. The former detail for each of hundreds of sectors the amount of each of hundreds of material purchases per dollar of production. The OEP output measures then translate these material input coefficients into estimated expenditures for each material input by any given sector for each year between 1984 and 1993. Material price indices are calculated by applying the BEA material weights for each sector to the BLS sectoral output price indices. This is the standard approach employed by the BLS and others in calculating detailed material price indices.

Capital

Information on capital usage by sector is based on the estimates of the Bureau of Economic Analysis, as reflected in the Detailed Industry Wealth Data Tape.[63] This data covers a wide range of distinct capital assets by industry. We have aggregated across these asset classes to focus on total capital usage for each industry. These include the current and constant dollar value of depreciation and gross stock. Information on actual interest paid by telecommunications firms is taken from the FCC's *Statistics of Communications Common Carriers.*[64] Interest rates represent annual average yield on new issues of high-grade corporate bonds from Business Cycle Indicators, compiled by the BEA.

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[62] *Benchmark Input-Output Accounts of the United States: 1987.* November 1994, Bureau of Economic Analysis.
[63] For further information, see *Fixed Reproducible Tangible Wealth in the United States, 1925-1989.* U.S. Department of Commerce, Economics and Statistics Administration, Bureau of Economic Analysis, 1993.
[64] Federal Communications Commission, *Statistics of Communications Common Carriers,* Page 3, Table 1.1, 1988 edition.

Labor

Total expenditures on labor are represented by total compensation of employees by industry from the Survey of Current Business, BEA.[65] The price of labor is from the Bureau of Labor Statistics Employment Cost Index[66] for U.S. Private Industry and Transportation and Public Utilities and from the BLS Average Hourly Earnings[67] for Total Private Industry and Telecommunications.

Telecommunications

The definition of telecommunications services is that employed by the BEA -- telecommunications services, SIC 48 except SIC 483, Radio and TV Broadcasting, and is consistent with the above-mentioned BEA input-output matrices and OEP data. Telecommunications services include "...establishments furnishing point-to-point communications services...and those engaged in leasing telephone lines or other methods of telephone transmission, such as optical fiber lines and microwave or satellite facilities, and reselling the use of such methods to others."[68] Consequently, all categories of telecommunications services have been accounted for: local, message toll, and interexchange services, including services provided by "competitive access providers" and public network "bypass."

The use of a telecommunications industry definition is preferable to a LEC definition for three reasons. First, most government data is published on an industry-wide definition. Second, factor input purchases are probably very similar for major sub-industry classifications. Third, an industry-wide definition entails the use of benchmarks which not only reflects a broader, less regulated set of firms, but is less susceptible to direct influence by LECs.

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[65] *Survey of Current Business*, U.S. Department of Commerce, Bureau of Economic Analysis, Table 6.4B, page 65, July 1986; Table 6.4B, page 79, July 1990; and Table 6.2C, page 88, July 1994.
[66] *Employment Cost Indexes and Levels, 1975-93* U.S. Department of Labor, Bureau of Labor Statistics, September 1993, Bulletin 2434, U.S. Private Industry and Transportation and Public Utilities Table 6, pages 38 and 45.
[67] *Employment and Earnings*, Bureau of Labor Statistics Department of Labor, Table C-2, Various Issues August 1985-86,89-91,93-94, and September 1987, Total Private Industry and Telecommunications.
[68] *Standard Industrial Classification Manual,* Executive Office of the President, Office of Management and Budget, 1987, p. 282.

Output and input data have been adjusted to reflect the exclusion of network access.[69] These payments from IXCs to LECs are excluded in order to better approximate LEC material inputs. Inclusion of these payments would have the effect of lowering the growth of telecommunications material prices below the results reported below.

[69] Federal Communications Commission, *Statistics of Communications Common Carriers,* Table 2.9, 1988-1989 edition.

4.0 Calculating Price Indices for Price Caps

4.1 Introduction

We can apply the double entry accounting framework presented in **Section 3.3** to address the issues raised in **Section 3.2** relative to assessing the validity of price caps for the telecommunications sector as calculated using the modified differential approach under the current LEC price cap formula and the proposed USTA TFP method. Essentially, this framework of the economy allows us to address two broad concerns with the modified differential price cap formula highlighted previously: 1) the misspecification of the inflation component to reflect economy-wide input price changes rather than economy-wide output price changes and then measuring this concept with the GDP-PI, a measure of final product sales prices, capturing one-third of the economy, and 2) the exclusion of the differential in input prices between the economy and the telecommunications sector. **Section 4** presents our analysis of the biases embedded in the components of the modified differential approach.

4.2 The Measure of Economy-wide Price Changes

Through its price cap proceedings, the FCC determined that the change in telecommunications output prices could be best calculated by measuring the change in general inflation less the net productivity change between the economy and the telecommunications sector. The original LEC Price Cap Plan adopted the GDP-PI as the measure of the general price changes in the economy and as a good proxy for the costs of factors of production faced by telecommunications providers.[70] The USTA's proposed TFP method also relies on the GDP-PI as the measure of inflation within the price cap formula. However, the GDP-PI is not a good measure of cost changes facing the total economy -- most importantly it excludes interindustry activity.

In **Section 3.3, Exhibit 1** presented a two-dimensional representation of total economic activity. This diagram demonstrates that a significant portion of economic activity takes place among producing firms. In fact, final demand, as measured by gross domestic product, is a relatively small percentage of the economy. Applying the previously described double entry accounting

[70] *Second Further Notice*, p. 320.

framework and linked government data, we calculate that gross domestic product (sales to final demand) represents approximately one-third of the economy. Two-thirds of the total economy, representing all non-capital domestic business-to-business transactions are excluded from this measure. Therefore, the GDP-PI would effectively capture price changes associated with approximately one-third of the total economy. An *economy-wide* measure of economic activity would include both the final demand component (GDP) and the measure of interindustry activity.

In addition to a fairly narrow definition of economic activity, gross domestic product as a measure of final demand is not an adequate representation of the purchases made by the producing sector. Personal consumption expenditures account for two-thirds of GDP. As a result, such consumer oriented sectors of the economy as retail trade, health services, and education make up over 30 percent of this measure (see **Exhibit 2**). While these sectors play an important role within the economy, they make up less than 20 percent of the economy-wide measure. A price measure reflecting such composition would not be expected to reflect the changes in prices for the economy as a whole, and certainly not for the producing sector.[71]

Exhibit 2
The Composition of Economy-wide Output Relative to Gross Domestic Product
(Industry share of inputs, 1987)

Economy-wide Output		**Gross Domestic Product**	
Supplying Industry	**Percent of Inputs**	**Supplying Industry**	**Percent of Inputs**
Retail Trade	8.9	Retail Trade	16.4
Construction	7.4	Construction	9.4
Wholesale Trade	6.2	Health Services	9.3
Education	4.6	Wholesale Trade	6.6
Health Services	4.7	Education	6.1
Cumulative Top 5	31.9	Cumulative Top 5	47.8

Note: Top five supplying sectors out of 49 sectors representing the entire economy. Source: Economy-wide output: Bureau of Labor Statistics Office of Employment Projection. Gross Domestic Product: *Benchmark Input-Output Accounts of the United States: 1987*, Bureau of Economic Analysis

The measure of economy-wide cost changes, therefore, differs compositionally and definitionally from the measure of price changes reflected in the GDP-PI. We see in **Exhibit 2** that a price index calculated with the double entry accounting framework to measure changes in economy-

[71] The compositional differences between the measure of final demand and economy-wide output, therefore, can result in significantly different measures of changes in output prices. For example, since the share of input attributed to health services is almost twice as much in the measure of GDP than in the economy-wide measure, we would find that the GDP-PI would be more heavily impacted by the recent escalation in health care costs.

wide prices performs significantly different from the GDP-PI. Economy-wide prices have not escalated at the same rate as reflected in the GDP-PI. As a result, the information presented in **Exhibit 3** demonstrates that the use of the GDP-PI in the modified differential approach overstates the measure of general economic price changes, as measured by the economy-wide output price index (EWOPI).[72] In fact, we calculate that the price of commodities and services excluded from the GDP-PI, i.e., non-capital domestic business to business transactions grew at a rate of only 2.13 percent per year over the 1984-1993 time frame, well below the rate of growth of the GDP-PI.

Exhibit 3
Net Effect of Using the Economy-Wide Output Price Measure Relative to the GDP-PI
(compound average annual growth rates)

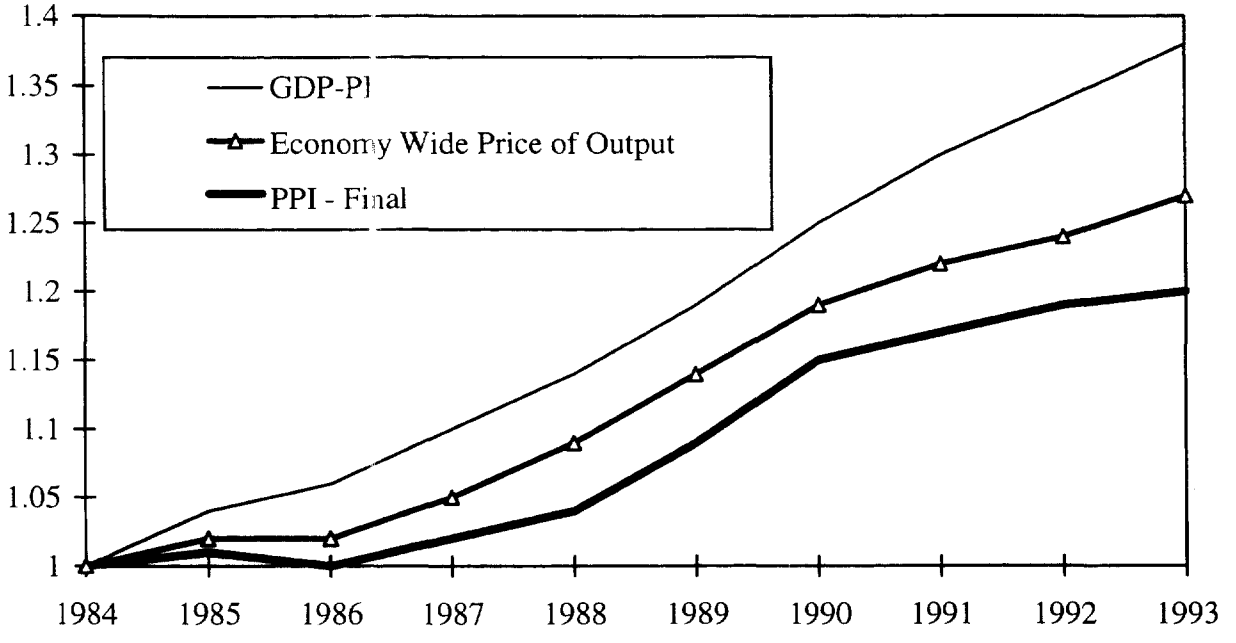
	GDP-PI	EWOPI	Difference
1984-1993	3.60	2.68	.92
1984-1989	3.59	2.63	.96
1990-1993	3.32	2.25	1.07

Source: Author calculations based on data from the United States Department of Commerce, Bureau of Economic Analysis: Survey of Current Business (GDP-PI); and, the Bureau of Labor Statistics, Office of Employment Projections (EWOPI).

Other readily available measures of the change in economy-wide prices were offered for consideration during the original AT&T price cap proceedings, including the Producer Price Index (PPI). The PPI captures changes in the producer prices for a fairly extensive set of industries, including utilities and communications. While this price index does not capture the breadth of information contained in the economy-wide output price, it is certainly a valid representation of price changes in a significant portion of the economy. However, while both the GDP-PI and the PPI track portions of the economy, neither index on its own is a good representation of economy-wide price changes. Below, in **Exhibit 4**, we provide a comparison of the GDP-PI, the PPI, and the EWOPI. The PPI for final goods and services has escalated at a rate of only 2.07 percent per year -- significantly below the GDP-PI's 3.6 percent. In fact, the PPI tracks very closely with our measure of overall price growth net of GDP-PI reported on the previous page.

[72] A similar issue was recently investigated by the Bureau of Labor Statistics. Specifically, the BLS is reviewing whether the use of a narrowly defined price index (the CPI) overstates cost of living increases, particularly when compared for policy purposes with a TFP measure calculated with a broader measure. See: *The Washington Post*, January 4, 1996.

Exhibit 4
The GDP-PI, the PPI and the Economy-Wide Output Price Index
(1984 = 1)



Source: GDP-PI: United States Department of Commerce, Bureau of Economic Analysis: Survey of Current Business. PPI: United States Bureau of Labor Statistics, Producer Prices Indexes. EWOPI: author calculations based on data from the Bureau of Labor Statistics, Office of Employment Projections.

4.3 Decomposing Factor Inputs: the Economy versus Telecommunications

As outlined in **Section 3.2**, by definition a differential approach to calculating a price cap for the telecommunications sector should include the differential between the input costs to the economy and the input costs to the telecommunications sector. The LEC price cap formula excludes this calculation, explicitly assuming the difference to be zero. In fact, several studies conducted by the LECs have suggested that statistical evidence supports the assumption that this input cost differential has been zero over history.[73] However, the double entry accounting framework, allows the inputs to the telecommunications sector and the economy to be compared. In fact, in our efforts to build a consistent and relevant data set we find significant definitional and compositional issues relative to the measurement of these inputs, underscoring the inherent difference in the behavior of these price indices.

Below we present the approach we employed in the development of the capital, labor and material input measures for the telecommunications sector and the economy. In this discussion we compare and contrast this approach to the measures of the factor inputs employed in previous analyses presented by the LECs that concluded that the input price differential is zero.

4.3.1 Compositional Differences at the Three Factor Level

As a first step, we calculate, the difference in input composition at the three factor input level. Using the above framework, we decompose the percentage of labor, capital, and material that, in aggregate, support economy-wide output and telecommunications output, respectively. **Exhibit 5** presents the significant difference in the proportional three-factor input composition of the U.S. economy and the telecommunications sector. Such differences would suggest at a very broad level that the aggregation of underlying three factor input price changes would lead to very different results.

[73] See for example "An Input Price Adjustment Would be an Inappropriate Addition to the LEC Price Cap Formula: Affidavit of Dr. Laurits R. Christensen on Behalf of the United States Telephone Association," CC Docket No. 94-1, February 1, 1995.